MASTER OF SCIENCE
IN
AERONAUTICAL ENGINEERING

PERFORMANCE OF A DUCTED MICRO-TURBOJET ENGINE
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A turbo-ramjet engine configuration has possible applications in missiles or unmanned aerial vehicle. In order to study possible configurations a Sophia J450 turbojet engine was used with varying shroud configurations to compare static thrust and specific fuel consumption measured in a test rig. A baseline shroud which covered the engine was tested with three ducts lengths aft of the J450's exhaust. Each duct length was tested with and without a final convergent nozzle. An elliptic intake for the shroud was also manufactured and tested on two of the configurations. Shroud pressures were also recorded to determine the amount of entrainment of secondary flow into the shroud. The short shroud was found to produce the best performance of the three configurations tested.

DoD KEY TECHNOLOGY AREA: Other (Turbojet, Ramjet)

KEYWORDS: Shroud, Nozzle, Intake

MINIATURE MUNITIONS/STORES FUNCTIONAL INTERFACE REQUIREMENTS
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A standard signal/data/power interface between a host aircraft and conventional aircraft stores is defined in MIL-STD-1760, the Department of Defense Interface Standard for Aircraft/Store Electrical (and Optical) Interconnection System. A new generation of smaller stores is being developed that are incompatible with the MIL-STD-1760 interface due to cost, size and technical constraints. The Society of Automotive Engineers is addressing the interface requirements for this new generation of miniature munitions/stores through its Miniature Munitions/Store Interface Task Group. This thesis helps define the electrical, physical and functional interface requirements for miniature munitions. It also investigates methods that will facilitate the efficient and cost effective transfer of required power, data and discrete signals needed for the safe and optimum carriage, deployment, and control of future miniature munitions and stores.

DoD KEY TECHNOLOGY AREAS: Conventional Weapons, Electronics, Sensors

KEYWORDS: Miniature Munitions, Stores, Weapons, Interface, Standards, MIL-STD-1760, GPS, Miniature Air Launched Decoy, Low Cost Autonomous Attack System, Small Bomb System

VERIFICATION OF ROTOR TRIM AND BALANCE SYSTEM (ROTABS) TO PERFORM ROTOR TRACK AND BALANCE ON THE MAIN ROTOR OF NAVY SH-60 HELICOPTERS

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Vibration analysis has proven to be an extremely effective tool for creating a smooth flying helicopter, especially in the area of reducing the 1/rev vibrations associated with main rotor track and balance. Current vibration analysis of the U.S. Navy's SH-60, 'Seahawk' helicopter is accomplished using a removable system called Vibration Analysis Test Set (VATS). The Navy is currently evaluating on-board automated diagnostic systems for future application in rotary wing aircraft. These systems are commonly referred to as Health and Usage Monitoring Systems (HUMS). B.F. Goodrich Aerospace holds a current Navy contract for such a system. B.F. Goodrich's proof of concept system is referred to as a Helicopter Integrated Diagnostic System (HIDS). One component of HIDS is the Rotor Trim and Balance System (ROTABS). ROTABS performs main rotor track and balance by using accelerometers to define the six axes of rotation, thus eliminating the need for an optical blade tracker. The goal of this thesis is to verify the ability of ROTABS software to perform main rotor track and balance on the SH-60 Helicopter without the need of a camera for blade tracking. During testing, VATS readings were utilized as truth data, and the current Navy vibration limitations represented the test standards.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Sensors

KEYWORDS: Helicopter, Rotary Wing, Rotor Trim and Balance System, ROTABS, Vibration Analysis Test Set, VATS, Health and Usage Monitoring Systems, HUMS, Helicopter Integrated Diagnostic System, HIDS, Integrated Mechanical Diagnostics, IMD, Track and Balance, Vibrations, Seahawk, SH-60

COMPUTATIONAL ANALYSIS OF THE OFF-DESIGN FLOWFIELD OF A MACH 6 $[(L/D)\ I_{sp}]_{max}$ OPTIMIZED WAVERIDER

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In a continuation of ongoing Naval Postgraduate School efforts to study the performance characteristics of waverider-configured vehicles, a computational fluid dynamic (CFD) analysis of the Mach 6 $[(L/D)\ I_{sp}]_{max}$ optimized Price waverider was conducted. This analysis was performed to determine the theoretical force and moment data over a broad Mach number spectrum, and to compare theoretical and experimental results in the subsonic flight regime. The CFD determination of force and moment data represents a continuation of the ongoing analysis of the Price waverider configuration. Selected viscous and inviscid flow solutions for flight conditions in the range $0.3 \le M_\infty \le 6.0$, as well as a subsonic ($M_\infty = 0.3$) angle of attack sweep, were conducted using NASA CFD software (OVERFLOW1.8b). Examination of the computed converged flowfield solutions suggests that the surface pressure distributions and Mach number contours surrounding the body are valid. Low speed force and moment coefficient data are shown to exhibit reasonable agreement with the available subsonic wind tunnel data. Additionally, supersonic CFD results show the development of the expected shock layer, exhibiting an attached shock bed at the design Mach number ($M_\infty = 6.0$). Evaluation of the computed Mach number effects on lift and drag coefficients at subsonic, transonic and supersonic Mach numbers suggests that the Price waverider may exhibit some flight instabilities across the flight Mach number spectrum.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Other (Hypersonic Flight, Computational Fluid Dynamics)

KEYWORDS: Air Vehicles, Hypersonic Flight, Computational Fluid Dynamics, Waverider Configurations

LOW COST PARACHUTE GUIDANCE, NAVIGATION, AND CONTROL

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The Affordable Guided Airdrop System (AGAS) integrates a low-cost guidance and control system into fielded cargo air delivery systems. This study evaluated the feasibility of this concept and included the design and execution of a flight test program to assess prototype system performance, as well as modeling efforts to develop initial guidance and control techniques leading to an evaluation of the feasibility of the AGAS concept. The flight test program provided adequate flight dynamic data for the AGAS system. The wind measurement techniques employed for this effort, through the use of a "calibration" parachute system, provided wind estimates that were not previously available. Flight test data demonstrated the actuator system could provide glide ratios of 0.4 to 0.5 for a flat circular parachute. A simulation was developed using a point mass model for parachute dynamics, sensor models, and a Bang-Bang type control system. Six hundred simulations demonstrated that the Affordable Guided Airdrop System shows strong potential of providing a low-cost alternative for precision airdrop. Further work is recommended to implement a six-degree of freedom dynamic model, assess the dynamic response of the production parachute system, and optimize the control algorithms to minimize fuel usage.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Aerodynamic Decelerators)

KEYWORDS: Parachutes, Guidance, Navigation, Control, Parameter Estimation

PRESSURE MEASUREMENTS ON A PROPOSED OPTICAL WINDOW FAIRING FOR THE ALTUS II UNMANNED AIR VEHICLE

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Low-speed wind tunnel tests were conducted to determine surface pressure measurements on a proposed aerodynamic fairing for the Altus II UAV. These tests were conducted at various angle-of-attack and sideslip positions to determine the effect on the surface pressures for the optical window portion of the fairing. Of particular interest were the pressure contour field located over the optical window region and the total force exerted on this area. Scaled-up loads (lbf) as calculated on the window ran from 1.0 to 1.6 times the freestream dynamic pressure (psf). Pressure measurements were also taken on the upper fuselage of the Altus II UAV model to determine the location of the peak suction area. These measurements provided the data to optimize the placement of external vents on the full-scale version of the airframe.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Sensors

KEYWORDS: Altus II UAV, Ultra-Violet Telescope, Fairing

INVESTIGATION OF FLOW OVER SECOND GENERATION CONTROLLED-DIFFUSION BLADES IN A LINEAR CASCADE

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This thesis contains a detailed investigation of second-generation controlled-diffusion compressor stator blades. The objective of the study was to compare the flow over and around the blades after the replacement of the tunnel motor, to that of previous studies. The inlet-flow angle was found to have increased from 39.5^{o} to 40^{o} with no movement of the blades in the tunnel. The blades were investigated at the new off-design inlet-flow angle using multiple experimental techniques. Surface flow visualization was used to view the overall blade surface flow characteristics. Blade surface pressure measurements were taken from an instrumented blade, and the distributions of pressure coefficients were calculated. A pressure rake probe was used to confirm the inlet endwall boundary layer thicknesses. Five-hole probe wake surveys were performed to determine loss coefficients and axial velocity ratios. Two-component laser Doppler velocimetry (LDV) was used to characterize the flow in the inlet, in the wake and the suction-side boundary layers of the blades.

Good correlation between techniques was found. The increased angle of incidence on the blades resulted in increased loading, and at the low Reynolds number, a smaller laminar separation bubble was observed.

DoD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Laser Doppler Velocimetry, Controlled-Diffusion Compressor Blading

HIGH POWER MICROWAVE SOURCE INTEGRATION WITH AN UNMANNED COMBAT AIR VEHICLE

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High Power Microwave (HPM) weapons integrated into an Unmanned Combat Air Vehicle (UCAV) will require significant amounts of power and presents the avionics with electric and magnetic field strengths that could cause damage or upset if vehicles are not adequately hardened. This thesis examines the power requirements and hardening issues associated with the integration of a High Powered Microwave system with an Unmanned Combat Air Vehicle. The power requirements assume a 300 foot altitude fly-over and a target incident power of 100 W/cm^2. Working back given component path loss efficiencies results in a required peak power level of 51.25 GW. Engine driven generators, integrated power units, thermal batteries, flywheels, and fuel cells were examined for possible solutions. All the power sources except fuel cells offer potential solutions meeting or exceeding average power requirements. Electromagnetic interference, compatibility, and hardening techniques were examined with specific design techniques provided. Both Vlasov and slot antennas enclosed in a bombbay with two square apertures were modeled using Hewlett Packard's High Frequency Structure Simulator. The electric and magnetic field strengths were obtained within the bombbay and outside, where the external field strength is due to electromagnetic propagation through the two square apertures. A comparison was also made with cutoff waveguide filters. The results demonstrate the near-term integration of an HPM source with a UCAV for target electronic kills is feasible.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Directed Energy Weapons, Modeling and Simulation

KEYWORDS: Unmanned Combat Air Vehicles, UCAV, Unmanned Air Vehicles, UAV, High Power Microwaves, HPM, Front Door Coupling, Back Door Coupling, Power Sources, Engine Driven Generators, Integrated Power Units, Thermal Batteries, Flywheels, Fuel Cells, Electromagnetic Interference, EMI, Electromagnetic Compatibility, EMC, Hardening, Shielding, High Frequency Structure Simulator, HFSS, Vlasov Antenna, Slot Antenna, Cutoff Waveguides

DEVELOPMENT OF A HELICOPTER VORTEX RING STATE WARNING SYSTEM THROUGH A MOVING MAP DISPLAY COMPUTER

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The need for improved pilot aids has become a high priority item for pilots and aircrews operating at sea and ashore. Pilot aids such as the moving map display, GPWS, collision, and vortex-ring state (VRS) warning systems will significantly enhance aircrew situational awareness and safety. Many more of today's aircraft mishaps are a result of pilot error, which includes a loss of situational awareness. The moving map display provides relatively easy incorporation of sophisticated pilot aids without operational flight program (OFP) modification. This thesis discusses, examines and selects a vortex-ring state prediction algorithm to be incorporated in the GADGHT unit. A program was written that manipulated required aircraft performance data from the ARINC 429 data bus and compared this data to vortex-ring state boundaries predicted by the algorithm. The GADGHT unit provides an audible and visual warning to the pilots when the aircraft has penetrated the VRS boundaries. This warning system will provide increased safety and situational awareness to helicopter crews operating in increasingly demanding operational environments.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Sensors

KEYWORDS: Moving Map Displays, Flight Planning Software, Vortex-Ring State, Power Settling, Settling With Power, Pilot Aid, Pilot Warning, Situational Awareness Aid, Safety